Alarming Signs in the Manchester Triage System: A Tool to Identify Febrile Children at Risk of Hospitalization

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Objectives To assess whether the flowcharts and discriminators of the Manchester Triage System (MTS) can be used as indicators of alarming signs of serious febrile illness to predict the risk of hospitalization for febrile children who present at the emergency department (ED).

Study design Observational study, which included 2455 children (<16 years) who came to the ED of a university hospital with fever as their main complaint (May 2007-July 2009). Alarming signs for serious febrile illness were matched with MTS flowcharts and discriminators. At triage, the percentage of alarming signs positive was calculated. The diagnostic ability of the percentage of alarming signs positive to identify children at risk of hospitalization was assessed by calculating positive and negative likelihood ratios.

Results Thirty percent of children had at least 1 alarming sign positive at triage. Twenty-three percent were hospitalized. Positive likelihood ratios of hospitalization were 5.0 (95% CI: 3.9-6.5) for children with >20% of alarming signs positive at triage and 12.0 (95% CI: 5.2-27.6) for those with >40% of alarming signs positive. Negative likelihood ratios were 0.8 (95% CI: 0.8-0.8) and 1.0 (95% CI: 0.9-1.0), respectively.

Conclusions By alternatively using the flowcharts and discriminators of the MTS as alarming signs, rather than urgency classifiers, the MTS can function as a simple, readily available tool to identify febrile children at risk of hospitalization early in the care process. This knowledge may help to improve ED throughput times as well as admission and discharge management at pediatric EDs. *(J Pediatr 2013;162:862-6)*.

Pediatric emergency departments (EDs) are becoming more and more crowded.[1] Febrile children constitute one of the major patient groups at pediatric EDs and are at risk of serious illnesses, like meningitis, sepsis, or pneumonia.[2,3] Prevalence of such infections ranges from about 7%-15%.[2-5] Early detection of serious febrile illnesses is important, because delaying or missing such diagnoses may lead to morbidity or even mortality and hospitalization is often required.[6-8] Recently, a systematic review has identified several alarming signs for serious illnesses in children with fever.[2]

Because the need for strategies to improve patient flows at pediatric EDs is growing, Asplin et al have proposed a conceptual input-throughput-output model to find areas for improvement of ED work flows.[9] One of the model's suggestions is that if one can already predict whether a patient will likely be admitted during the intake-phase (eg, triage), timeliness of admission to the ward or discharge management can be improved.[1,9]

The Manchester Triage System (MTS)[10,11] is implemented in a large scale and used to prioritize patients according to acuity.[3,12-16] The MTS contains flowcharts (presenting problem) and discriminators (other signs and symptoms) for triage of both adult and pediatric patients and collects clinical information at the moment of arrival at the ED.

This study aimed to assess whether the flowcharts and discriminators of the MTS can be used as indicators of alarming signs of serious febrile illness, rather than urgency classifiers alone, to predict the risk of hospitalization for febrile children who present at the ED.

Methods

This observational study is part of an ongoing study on validation of the MTS, for which standardized clinical information is prospectively and electronically collected.[12,17] The institution's medical ethics committee approved the study and the requirement for informed consent was waived.

We included all children up to 16 years of age who had came to the ED of the Sophia Children's Hospital, Rotterdam, The Netherlands, from May 2007-July 2009. This ED is part of the Erasmus University Medical Center and provides care to approximately 9000 children annually (ie, 50% general pediatrics, 40%

ED	Emergency department
IV	Intravenous
MTS	Manchester Triage System

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surgery, 10% other specialties).[18] Eligible contacts were those who had general pediatric problems and: (1) fever as the reason for contact; (2) fever selected as triage discriminator; or (3) a rectal temperature ≥38.5°C measured at the ED. Revisits for the same complaint within 7 days were excluded, as were children who died at the ED.

All children who presented at the ED were routinely triaged with the MTS. The MTS consists of 49 flowchart-diagrams which represent main problems with which children present to the ED (eg, 'crying baby' or 'shortness of breath'). Each flowchart is built up of a specific combination of discriminators (ie, signs and symptoms that often go hand-in-hand with the presenting problem). Within each flowchart, the discriminators are arranged from most urgent (U1, top) to least urgent (U5, bottom) (**Figure 1**; available at www.jpeds.com). At triage, trained nurses first have to select the most appropriate flowchart for the child. Next, the patient's urgency level is assessed by selection of the most relevant discriminator, starting from the top of the flowchart moving downwards.

For the purpose of this study, triage nurses also had to indicate whether the other discriminators within the flowchart were present or absent ('triage remaining items'). In our hospital, a modified version of the first edition of the MTS (official Dutch translation)[10] was used, which contained several adjustments for triage of febrile children.[19] Compliance with triage was 97% (7311/7573). Inter-rater agreement (agreement in triage urgency level if multiple nurses triage one patient) and intra-rater agreement (agreement in triage urgency level if 1 triage nurse triages 1 case scenario at different time points) have been shown to be good for the MTS, both at our own ED and other setting[20,21] and were not influenced by nurses' work experience.[21]

Patient's characteristics, selected flowchart, selected discriminators, urgency category, and hospitalization were extracted from the computerized MTS. Medical records were checked manually for children who missed 1 or more triage remaining items (N = 262; 3.5%). For 47 (1.8%) patients, some triage remaining items remained missing and were assumed to be absent. Among all evaluated in the ED, 0.5% left before being seen by a physician. These patients were not followed up, because this number was very small and will not have influenced our results.

We matched alarming signs for serious illness, as identified in a systematic review (positive likelihood ratio >5 or negative likelihood ratio <0.2),[2] with flowcharts and discriminators of the MTS. Three flowcharts and 20 discriminators were considered as valid proxies for 14 alarming signs (**Table I**). The alarming signs 'child moaning,' 'crackles,' and 'decreased breathing sounds' could not be matched with any flowchart or discriminator. Two alarming signs were excluded from the analysis: 'decreased skin elasticity' was specific for only gastro-enteritis with subsequent dehydration and 'any abnormal finding in history or physical examination' we found too unspecific for triage purposes.

Because every flowchart contains a unique combination of discriminators, relevant for the presenting problem, the maximum number of alarming signs that could have been selected at triage of a child was dependent on the assigned flowchart and ranged from 1-7. For example, in the flowchart 'crying baby' (**Figure 1**), 8 discriminators are valid proxies for 6 alarming signs in total. To correct for the difference in the maximum number of alarming signs between flowcharts, we calculated the percentage of alarming signs positive at triage as follows:

$$\text{Percentage of alarming signs positive} = \frac{\text{number of alarming signs present at triage, given the assigned flowchart}}{\text{maximum number of alarming signs available in the assigned flowchart}}$$

The primary outcome measure of this study was hospitalization. At our study ED, the admission policy was based on medical indications only: (1) abnormal or threatened vital signs; (2) requirement of intravenous (IV)-medication or IV-fluids; or (3) failure to ingest medication (eg, need for a nasogastric tube). To validate our assumption that hospitalization could be used as a proxy for serious febrile illness, we evaluated the number of diagnostic and therapeutic interventions performed during hospital admission and the definite diagnosis in a random subsample of admitted children (January 2008-July 2009; N = 356).

Statistical Analyses

The majority of patients (77%) were assigned to flowcharts in which the maximum number of alarming signs that could be selected was 5 (flowcharts 'general,' 'shortness of breath,' and 'vomiting and diarrhea') or 7 (flowcharts 'worried parent' and 'fits'). In our analyses, we, therefore, categorized the percentage of alarming signs positive as such that for children assigned to these flowcharts the categories corresponded with 'no alarming signs positive at triage' (0%; 'none'), '1 alarming sign positive at triage' (≤20%, 'low'), '2 alarming signs positive at triage' (≤40%, 'intermediate'), and '3 or more alarming signs positive at triage' (>40%, 'high').

Two-by-two contingency tables were constructed to show the distribution of hospitalizations among the 4 percentage groups. To determine the diagnostic value of the percentage of alarming signs to assess the need for hospitalization, as if it were a diagnostic test, we calculated sensitivity, specificity, and positive and negative likelihood ratios with 95% CIs (VassarStats Clinical Calculator; http://vassarstats.net/clin1.html). To indicate a 'positive' and 'negative' test result, we dichotomized the percentage of alarming signs at the 3 cut-off points: (1) >0% versus no alarming signs; (2) more than 20% of alarming signs positive (>20% vs ≤20%); or (3) more than 40% of alarming signs positive (>40% vs ≤40%). For descriptive statistics we used SPSS PASW statistics software (v. 17.0.2; SPSS Inc, Chicago, Illinois).

Results

In total, 2455 (32%) of 7573 children were eligible for analyses (**Figure 2**). No differences in age, sex, temperature, and frequency of hospitalization were found between children